UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 591

Contribution from the Bureau of Markets
CHARLES J. BRAND, Chief

Washington, D. C. PROFESSIONAL PAPER December 26, 1917

MANUFACTURING TESTS OF THE OFFICIAL COTTON STANDARDS FOR GRADE

By

WILLIAM S. DEAN, Assistant in Cotton Testing
and FRED TAYLOR, Cotton Technologist

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By WILLIAM S. DEAN, *Assistant in Cotton Testing*, and FRED TAYLOR, *Cotton Technologist.*

CONTENTS.

INTRODUCTION.

The spinning tests herein described [1] were conducted for the purpose of determining the relative intrinsic values of cotton of the grades of Middling Fair, Good Middling, Middling, Low Middling, and Good Ordinary.

The principal factors considered in making the tests were: (1) The percentage of waste; (2) the tensile strength of the yarn; (3) the bleaching properties of the yarn and cloth; (4) the moisture content; and (5) other manufacturing properties of the cotton.

[1] The cotton was purchased by Messrs. D. E. Earle, D. C. Griffith, W. C. Neale, and Hal Brown, cotton specialists. The grading was done by the board of examiners (a committee authorized to hear disputes under the provisions of the U. S. cotton futures Act). The tests, spinning and weaving, were conducted in representative mills at Fall River, Mass., and in the textile department of the North Carolina State College of Agriculture and Engineering, West Raleigh, N. C., under the general supervision of Fred Taylor, cotton technologist, and D. E. Earle, specialist in cotton classing, and were made by William S. Dean, assisted by George H. Anderson, assistant in cotton classing, and Messrs. J. J. W. Cooper, C. E. Coburn, C. E. Killingsworth, R. V. Hellams, and H. B. Richardson, assistants in agricultural technology. The bleaching tests were made by W. S. Dean and Prof. Everett H. Hinckley, in charge of chemistry, New Bedford Textile School, New Bedford, Mass., at bleacheries in Fall River and in the New Bedford Textile School.

NOTE.—This bulletin should be of interest to cotton producers, manufacturers, and dealers.

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ORIGIN OF THE COTTON.

Cotton of each grade, approximately $\frac{15}{16}$ inch to 1 inch in length of staple, was purchased from the following zones or sections of the cotton belt: Piedmont Plateau, Atlantic Coastal Plains, eastern Gulf Coastal Plains, western Gulf Coastal Plains, and the western Prairie Lands and Plateau. These zones, or sections, are recognized as producing cotton of different character, largely because of differences in soil or of climatic conditions.

The cotton used was from the 1914 crop and was purchased during the months of May and June, 1915. The Middling Fair cotton was slightly below the standard grade, suitable cotton of that grade not being on the market at the time of purchase.

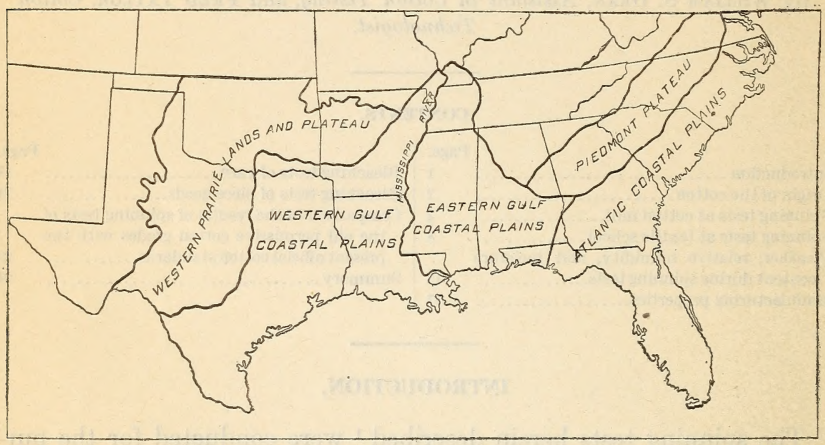


FIG. 1.—Map showing the different zones from which cotton used in the tests was purchased.

Samples were taken from 12 different parts of each bale and graded by members of the board of examiners, a committee authorized to hear disputes under the provisions of the United States cotton futures Act, and rejections were made of bales not uniform in grade and staple.

SPINNING TESTS AT COTTON MILL.

The upland cotton produced east of the Mississippi River and that produced west of the Mississippi (see fig. 1) were tested separately by grades in a cotton mill in Fall River, Mass.

METHODS OF COMPARISON.

The bales of cotton representing the five grades were weighed carefully on the same day, and these weights, less the weight of tare, were used as the basis of calculations in making the spinning tests. In each case the different bales of cotton of the same grade

were mixed thoroughly. The cotton was run through a bale breaker and then through an air pipe, which conveyed it a distance of approximately 200 feet, where it was deposited in a large pile. Invariably this was done late in the afternoon, and the loose cotton was left in this condition over night.

While the cotton was passing through the breaker and finisher pickers and cards total weights of the stock were obtained after each process on scales sensitive to half an ounce. The different grades were run through the same machines and subjected to the same speeds, settings, drafts, etc., throughout all the manufacturing processes, subject to such changes as were necessary to maintain a correct weight of the stock. The cards were stripped at regular intervals in conformity with the best mill practices. There was no intermediate process of doubling in the picker room; therefore three processes of drawings were used. The bands, spindles, rolls, etc., on the spinning frame were examined carefully in order to eliminate in so far as possible such mechanical defects as would tend to reduce or vary the quality of the product.

Table I gives the organizations of the machines used in the manufacture of 22's yarn.

TABLE I.—*Organization of machinery for 22's yarn.*

Machine.	Actual draft.	Doubling.	Size.	Twist per inch.
Pickers:				
Bale breaker—				
Opener and breaker (combined)			16-oz. lap	
Finisher	4.50	4	13½-oz. lap	
Cards	99.65	1	56 grains	
Drawing frames:				
First drawing	5.38	6	62.5 grains	
Second drawing	5.43	6	69 grains	
Third drawing	5.52	6	75 grains	
Fly frames:				
Slubber	4.5	1	0.5 hank roving.	0.85
Intermediate	5.60	2	1.40 hank roving.	1.42
Fine	6.28	2	4.4 hank roving.	2.51
Spinning:				
Ring frame	10	2	22	22.23 warp.
Ring frame	10	2	22	17.50 filling.

WASTE PERCENTAGES.

The percentages of waste discarded in the manufacturing processes from each of the five grades of cotton of both the eastern and western upland lots are found in Table II. These percentages were computed in the following manner: The waste discarded at each machine was considered as being a certain percentage of the net amount of cotton fed into that machine, but the total percentages as given "through the card" were based on the net amount of cotton fed into the first waste-cleaning machine. The tare on the bales was not included in these calculations.

TABLE II.—*Waste percentages of different grades of Eastern Upland and Western Upland cotton (mill tests).*

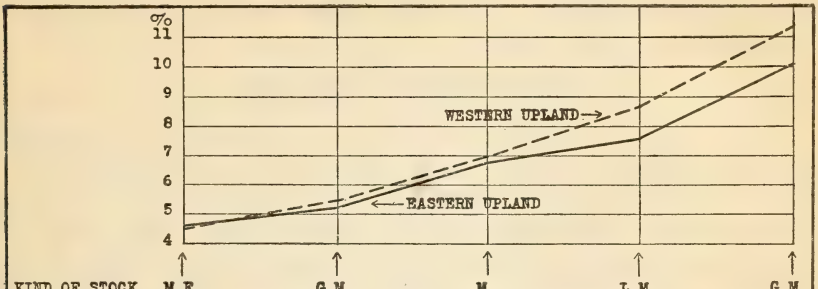
		Eastern stock.					Western stock.				
		M. F.[1]	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.
Net weight fed to picker	pounds	2,810.00	3,950.50	4,586.12	5,075.38	5,386.63	2,223.00	4,965.00	4,662.37	4,238.87	5,317.44
Machines.	*Kinds of waste.*										
Pickers	Visible:										
	Opener, motes and fly	0.16	0.32	0.59	0.69	1.29	0.27	0.31	0.63	0.88	1.32
	Breaker, motes and fly	.20	.31	.45	.71	1.02	.22	.32	.51	.71	1.10
	Finisher, motes and fly	.42	.50	.83	1.05	1.56	.37	.52	.91	1.28	1.75
	Total visible	.78	1.13	1.87	2.45	3.87	.86	1.15	2.05	2.87	4.17
	Invisible	3.18	3.03	3.53	4.22	5.08	3.06	3.40	3.74	4.03	4.66
	Total visible and invisible	3.96	4.16	5.40	6.67	8.95	3.92	4.55	5.79	6.90	8.83
Cards[2]	Visible:										
	Flat strippings	2.36	2.51	2.71	2.66	2.96	2.34	2.55	2.67	2.93	3.31
	Cylinder and doffer strippings	.45	.41	.51	.52	.54	.34	.45	.51	.55	.60
	Motes and fly	1.07	1.24	1.80	2.12	2.99	1.06	1.27	1.82	2.44	3.58
	Sweepings	.16	.10	.16	.20	.32	.11	.20	.18	.30	.29
	Total visible	4.04	4.26	5.18	5.50	6.81	3.85	4.47	5.18	6.22	7.78
	Invisible	.83	.52	.38	.46	.53	.63	.55	.85	.73	1.06
	Total visible and invisible	4.87	4.78	5.56	5.96	7.34	4.48	5.02	6.03	6.95	8.84
Pickers and cards[3]	Visible	4.66	5.21	6.77	7.58	10.08	4.56	5.42	6.93	8.66	11.26
	Invisible	3.97	3.54	3.89	4.65	5.56	3.66	3.93	4.54	4.71	5.63
	Total visible and invisble	8.63	8.75	10.66	12.23	15.64	8.22	9.35	11.47	13.37	16.89

[1] The grades of cotton are indicated in the tables of this bulletin as follows: M. F. = Middling Fair; G. M. = Good Middling; M. = Middling; L. M. = Low Middling. G. O. = Good Ordinary.

[2] Based on net weight fed to cards.

[3] Based on net weight fed to pickers.

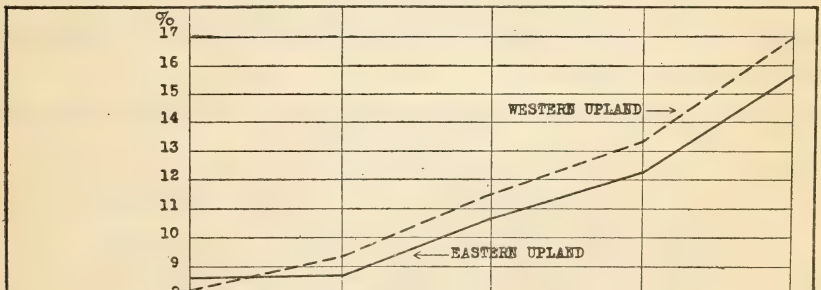
A study of Table II shows a close relationship between the percentages of waste discarded in the manufacturing processes and the corresponding grades of cotton. The percentages of waste increase consistently as the grades of the cotton decrease in quality from Middling Fair to Good Ordinary. The amount of invisible waste is com-



KIND OF STOCK	M.F.	G.M.	M.	L.M.	G.M.
EASTERN UPLAND	4.66	5.21	6.77	7.58	10.08
WESTERN UPLAND	4.56	5.42	6.93	8.66	11.26

FIG. 2.—Visible waste percentage of five grades of both Eastern Upland and Western Upland cotton. (Mill tests.)

paratively regular, indicating uniformity in the moisture content of the cotton while it was being manufactured. In the manufacture of western upland cotton a somewhat increased amount of waste, as compared with the corresponding grades of eastern upland cotton, was discarded. However, these figures are not conclusive because they indicate the results obtained from the crop of only one year.



KIND OF STOCK	M.F.	G.M.	M.	L.M.	G.O.
EASTERN UPLAND	8.63	8.75	10.66	12.23	15.64
WESTERN UPLAND	8.22	9.35	11.47	13.37	16.89

FIG. 3.—Combined visible and invisible waste percentages of five grades of both Eastern Upland and Western Upland cotton. (Mill tests.)

Figure 2 represents graphically the total visible waste percentages of the five grades of both eastern upland and western upland cotton. The combined visible and invisible waste percentages of the five grades of eastern upland and western upland cotton are represented graphically in figure 3. The figures given in the table below each

graph were taken from Table II and placed in this position for convenient reference. The close relationship between the cotton from the two sections of the cotton belt and the relationship between the grade and the percentage of waste are apparent.

It should be borne in mind that the greater part of the cotton taken out as waste has a commercial value, since it is used in various branches of the waste industry.

TENSILE-STRENGTH COMPARISONS.

In order to test the yarn produced from each grade of cotton under uniform conditions, tensile-strength tests were conducted in the laboratory of the Bureau of Markets, United States Department of Agriculture, at Washington, D. C. Cotton is hygroscopic, and any change in atmospheric moisture affects the tensile strength of the material. The laboratory is equipped with humidifiers which are regulated by an automatic control within approximately 1 per cent.

Skeins of 120 yards each were reeled off the bobbins of yarn made from the different grades of cotton and placed separately on racks constructed for this purpose. After a sufficient number of skeins had been reeled off to give positive results[1] they were allowed to condition in the testing room, having a temperature of 70° F. and a relative humidity of 65 per cent. Subsequently they were taken from the racks one at a time in rotation and broken with a power yarn tester, the downward stroke of the traverse moving at the rate of approximately 12 inches per minute.

Table III gives the result of the tensile-strength tests of 22's warp yarns made from five grades of eastern upland and five grades of western upland cotton.

TABLE III.—*Comparative tensile strength of 22's yarns in pounds per skein of 120 yards (mill tests).*

Twist[1] constant.	Eastern upland.						Western upland.					
	M. F.	G. M.	M.	L. M.	G. O.	Av.	M. F.	G. M.	M.	L. M.	G. O.	Av.
4.20	75.9	76.0	75.2	72.3	70.4	74.0	84.1	85.7	83.7	72.2	76.6	80.5
4.54	75.7	76.4	74.4	73.1	67.5	73.4	86.3	82.1	82.3	73.3	75.9	80.0
4.74	74.1	75.8	70.5	71.0	66.4	71.6	82.4	79.0	79.1	69.7	75.1	77.1
4.95	72.5	69.8	69.8	69.6	67.6	69.9	82.7	78.9	78.5	69.1	71.9	76.2
Average	74.6	74.5	72.5	71.5	68.0	72.2	83.9	81.4	80.9	71.1	74.9	78.5

[1] See footnote, p. 17.

Table III shows that the grade of the cotton does not always govern the tensile strength of the yarn.

During the month of June, 1915, within which this cotton was purchased, it was not possible to secure different grades of cotton

[1] By taking subtotals and averaging the tensile strength it was found that 24 skeins usually were sufficient.

from over equally distributed areas in each section or zone where it was produced. This was especially true in the sections west of the Mississippi River. The soil and weather conditions often vary considerably within the same zone, and even if several bales of cotton originated from the same locality it is entirely possible for conditions to affect the tensile strength of the yarn differently.

The inconsistent variations shown by the tensile-strength test suggest to the manufacturer who wishes to maintain more uniform results in the manufactured product the importance of thorough mixing.

In practically every case the yarn made from western upland cotton was stronger than that made from the corresponding grades of eastern cotton, the difference being from 5 to 9 pounds per skein of 120 yards. This observation sustains the prevailing opinion that western upland cotton produces a stronger yarn than eastern, because its staple is of a heavier body. The fibers are greater in diameter and more wiry. For these reasons it is better suited for warp yarns than eastern upland cotton. The latter is better suited for filling and hosiery yarns because of its softness and pliability. However, in the waste cleaning processes western upland cotton lost more than eastern upland cotton.

Figure 4 shows graphically a comparison of the tensile strength in pounds per skein of 120 yards each of yarn made from eastern upland and western upland cotton. The 22's warp yarn with 22.23 turns per inch, or a twist constant [1] of 4.74, was used for this comparison.

Table III also shows the effect of the different twists per inch in the manufacture of 22's yarn made from the five grades of eastern and western upland cotton, respectively. There were used four twist constants, namely, 4.20, 4.54, 4.74, and 4.95, which represent, respectively, 19.7, 21.31, 22.23, and 23.22 turns of twist per inch.

Contrary to the general belief, the twist constant 4.74, the nearest obtainable to 4.75, which is considered as the warp yarn standard for upland cotton, did not produce the strongest yarn, showing that the points at which twist added strength to the yarn had been exceeded. (See also Table V, Textile school tests.) The turns per inch inserted in the yarn were verified by actual count after the yarn had been spun.

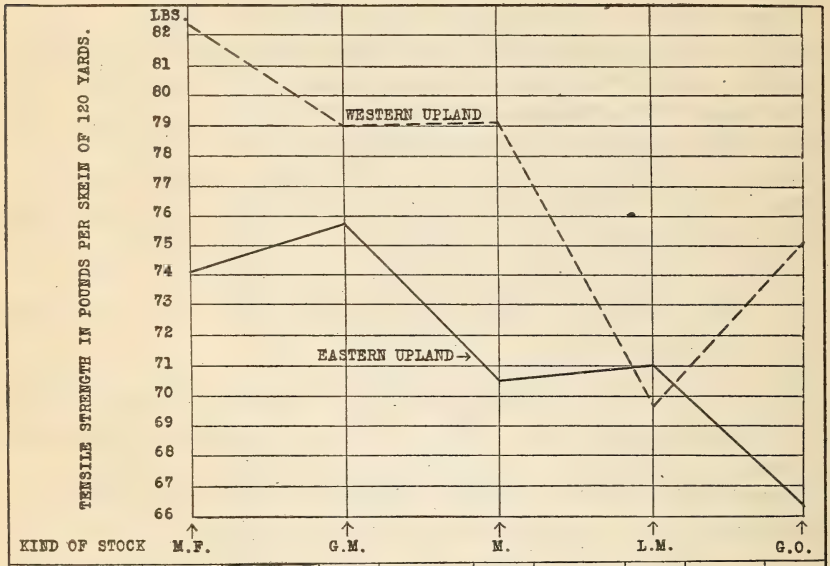
While the purpose of these tests was primarily to determine the relative percentages of waste in the different grades of cotton, the wide variation in the tensile strength served to show that the grade and staple of cotton does not always indicate accurately the strength of the yarn. Some other characteristics influencing the quality of

[1] Twist constant 4.75 is considered as standard for warp yarns, upland cotton. The twist per inch inserted in the yarn will be found by multiplying the square root of the number of yarns by the twist constant.

the manufactured product, especially the tensile strength, can not be recognized by the present inexact method of judging the quality of raw cotton. Irregularities in the manufactured product are minimized by adequate methods of mixing the cotton for manufacturing.

SPINNING TESTS AT TEXTILE SCHOOL.

It was deemed advisable to make tests under different conditions; therefore, tests were made both in commercial mills and in textile schools.



KIND OF STOCK	M.F.		G.M.		M.		L.M.		G.O.
EASTERN UPLAND	74.1		75.8		70.5		71.0		66.4
WESTERN UPLAND	82.4		79.0		79.1		69.7		75.1

FIG. 4.—The tensile strength of 22's warp yarn, made with 4.74 twist constant from the different grades of Eastern Upland and Western Upland cotton. (Mill tests.)

Fifty pounds from each of the 109 bales tested in the mill were sent to the textile department of the North Carolina State College of Agriculture and Engineering, West Raleigh, N. C. In conducting these tests the cotton originating from each of the different zones shown in figure 1 was tested separately. The mechanical conditions were made to duplicate as nearly as possible the conditions prevailing during the mill test. (See Table I.) In the textile-school tests the cotton passed through the following waste-cleaning machines: Opener and finisher, pickers, and cards.

TABLE IV.—*Waste percentages of the different grades of cotton from the different zones (textile-school tests).*

Zones	Piedmont Plateau.					Atlantic Coastal Plains.					Eastern Gulf Coastal Plains.					Western Gulf Coastal Plains.					Western Prairie Lands and Plateau.				
Grades	M. F.	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.
Net weight fed to pickers, pounds	45.06	147.25	144.63	192.62	244.06	98.12	197.00	193.37	146.44	191.31	96.56	142.94	193.31	241.69	241.13	96.06	144.62	186.69	190.25	239.88	144.93	375.50	331.07	329.25	533.37
Machines and kinds of waste.																									
Pickers:																									
Visible—																									
Breaker, motes and fly	.26	.38	1.00	1.10	1.95	.57	.70	.97	1.28	2.09	.38	.70	1.06	1.40	2.39	.52	.60	.94	1.12	2.20	.48	.52	1.19	1.44	2.32
Finisher, motes and fly	.22	.34	.88	.82	1.40	.45	.52	.73	1.04	1.52	.40	.52	.79	1.18	1.73	.48	.49	.86	1.11	1.71	.33	.49	.97	1.13	1.74
Total visible	.48	.72	1.88	1.92	3.35	1.02	1.22	1.70	2.32	3.61	.78	1.22	1.85	2.58	4.12	1.00	1.09	1.80	2.23	3.91	.81	1.01	2.16	2.57	4.06
Invisible	[1].06	.09	.65	1.11	1.02	[1]1.28	.10	.03	[1].33	.70	[1].91	[1].87	.24	.95	.96	[1].58	[1].26	[1].12	[1].62	1.61	.11	[1].81	.39	[1].30	.94
Total visible and invisible	.42	.81	2.53	3.03	4.37	[1].26	1.32	1.73	1.99	4.31	[1].13	.35	2.09	3.53	5.08	.42	.83	1.68	1.61	5.52	.92	.20	2.55	2.27	5.00
Cards:[2]																									
Visible—																									
Flat strippings	2.54	2.40	2.78	2.66	3.08	2.87	2.43	2.84	2.95	3.21	2.81	2.77	2.86	3.07	3.64	1.95	1.94	2.44	2.60	2.86	2.17	2.32	2.71	3.12	3.78
Cylinder and doffer strippings	.65	.56	.88	.96	.95	1.01	.77	.97	1.00	.92	.82	.71	.69	.92	1.04	.74	.58	.74	.77	.91	.50	.72	.92	1.05	1.39
Motes and fly	1.05	1.18	1.80	1.92	3.04	1.58	1.26	1.62	2.05	2.75	.96	1.43	1.77	2.80	3.81	1.20	1.41	2.05	2.56	3.32	1.11	1.27	1.87	2.49	4.12
Sweepings	.15	.22	.15	.06	.20	.35	.15	.18	.13	.15	.14	.11	.15	.18	.21	.23	.09	.19	.15	.28	.20	.08	.15	.13	.09
Total visible	4.39	4.36	5.61	5.60	7.27	5.81	4.61	5.61	6.13	7.03	4.73	5.02	5.47	6.97	8.70	4.12	4.02	5.42	6.08	7.37	3.98	4.39	5.65	6.79	9.38
Invisible	[1].25	.31	0.00	.21	[1].06	[1]1.15	.04	0.00	[1].19	.12	[1].30	[1].20	.15	.12	.03	[1].37	[1].15	[1].35	[1].04	.20	[1]1.21	[1].02	[1].20	.61	[1].25
Total visible and invisible	4.14	4.67	5.61	5.81	7.21	4.66	4.65	5.61	5.94	7.15	4.43	4.82	5.62	7.09	8.73	3.75	3.87	5.07	6.04	7.57	2.77	4.37	5.45	7.40	9.13
Pickers and cards:[3]																									
Visible	4.85	5.05	7.34	7.35	10.30	6.84	5.77	7.21	8.33	10.33	5.52	6.22	7.20	9.30	12.37	5.10	5.07	7.13	8.21	10.87	4.75	5.39	7.66	9.21	12.97
Invisible	[1].31	.40	.65	1.31	.96	[1]2.43	.14	.03	[1].52	.82	[1]1.21	[1]1.07	.39	1.07	.99	[1].95	[1].41	[1].46	[1].66	1.80	[1]1.09	[1].83	.20	.30	.70
Total visible and invisible	4.54	5.45	7.99	8.66	11.26	4.41	5.91	7.24	7.81	11.15	4.31	5.15	7.59	10.37	13.36	4.15	4.66	6.67	7.55	12.67	3.66	4.56	7.86	9.51	13.67
Average loss for each zone	7.58					7.30					8.16					7.14					7.85				

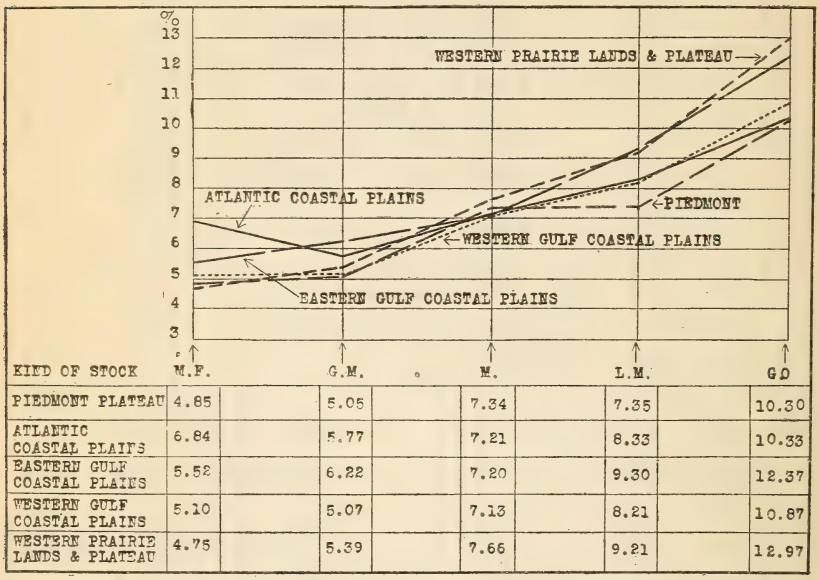
[1] Gain.

[2] Based on the net weight fed to the cards.

[3] Based on the net weight fed to the pickers.

WASTE PERCENTAGES.

Table IV gives the results of the waste determinations as found in the textile-school tests. These figures were computed in the same manner as those in Table II. Net weights were used in making calculations, the tare not being included. Since approximately 50 pounds from each bale were used in the textile-school tests, the number of different bales of each grade represented is shown by the total weight given for each grade. The waste percentages of the five grades from the different zones are placed side by side in order to facilitate comparison.



KIND OF STOCK	M.F.	G.M.	M.	L.M.	G.O.
PIEDMONT PLATEAU	4.85	5.05	7.34	7.35	10.30
ATLANTIC COASTAL PLAINS	6.84	5.77	7.21	8.33	10.33
EASTERN GULF COASTAL PLAINS	5.52	6.22	7.20	9.30	12.37
WESTERN GULF COASTAL PLAINS	5.10	5.07	7.13	8.21	10.87
WESTERN PRAIRIE LANDS & PLATEAU	4.75	5.39	7.66	9.21	12.97

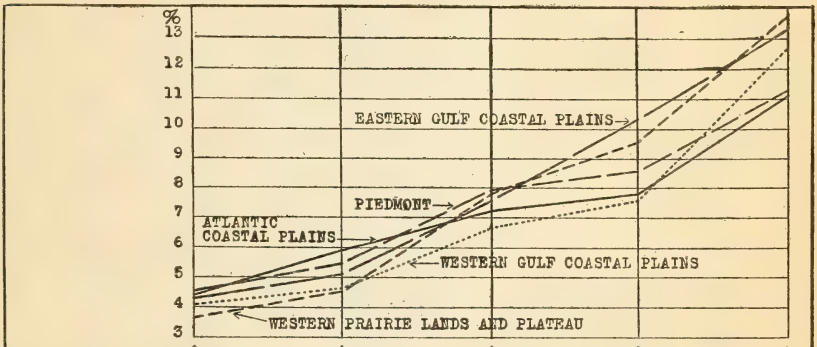
FIG. 5.—The visible waste percentages of five grades of cotton from the different zones. (Textile school tests.)

A close analysis of these percentages shows that the waste has a consistent relationship to the grade of the cotton. The percentages of invisible waste, however, are neither as uniform nor as consistent as are the percentages of visible waste. (See discussion of Moisture, page —.)

Figure 5 represents graphically the percentages of visible waste in the cotton originating from each of the five zones and of the five grades tested from each zone. Figure 6 likewise represents the percentages of visible and invisible waste combined. There is relatively little variation between the percentages of waste in cotton of the same grade from the different zones.

The average percentages of total waste from the five grades from the Piedmont Plateau, Atlantic Coastal Plains, eastern Gulf Coastal Plains,

western Gulf Coastal Plains, and the western Prairie Lands and Plateau are as follows: 7.58, 7.30, 8.16, 7.14, and 7.85, respectively. These figures are not given, however, as a criterion nor with the inference that such close relationship would always prevail. As a matter of fact, material differences in the percentage of waste for the same grade often are found in neighboring sections of the country. A number of the large manufacturers early in the cotton season each year test carefully various lots from several different sections of the cotton belt to determine which cotton is best suited for their use.



KIND OF STOCK	M.F.	G.M.	M.	L.M.	G.O.
PIEDMONT PLATEAU	4.54	5.45	7.99	8.66	11.26
ATLANTIC COASTAL PLAINS	4.41	5.91	7.24	7.61	11.15
EASTERN GULF COASTAL PLAINS	4.31	5.15	7.59	10.37	13.36
WESTERN GULF COASTAL PLAINS	4.15	4.66	6.67	7.55	12.67
WESTERN PRAIRIE LANDS & PLATEAU	3.66	4.56	7.86	9.51	13.67

FIG. 6.—The combined visible and invisible waste percentages of five grades of cotton from the different zones. (Textile school tests.)

TENSILE-STRENGTH COMPARISONS.

(Textile-school tests.)

The tensile-strength tests of the yarn spun from the cotton originating in the various zones were made as described on page 6. Table V gives the results of these tests for the different zones and the same grades from each zone. No. 22's yarn was used in each case. Three different twist constants were used in order to determine the relative tensile strength of yarns made from upland cottons with different twists per inch.

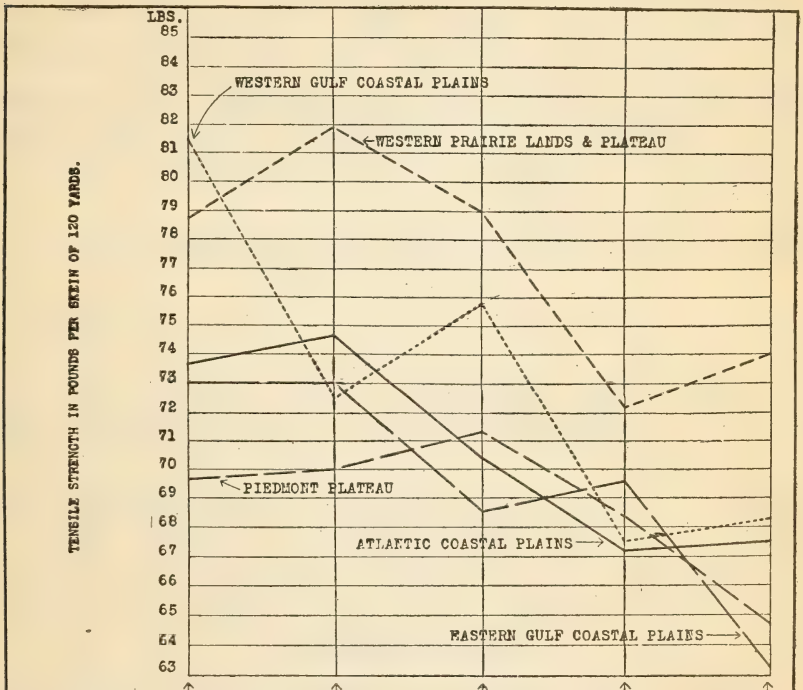
TABLE V.—*Tensile-strength comparisons of 22's yarn in pounds per skein of 120 yards each (textile-school tests).*

Zone.	Twist constants.	M. F.	G. M.	M.	L. M.	G. O.	Average.
Piedmont Plateau	4.29	70.8	71.9	73.4	70.0	64.0	70.0
	4.53	73.6	73.2	75.6	74.7	69.2	73.3
	4.76	69.7	70.0	71.3	68.3	64.7	68.8
Average		71.4	71.7	73.4	71.0	66.0	70.7
Atlantic Costal Plains	4.29	74.1	75.1	70.5	68.4	68.2	71.3
	4.53	77.5	77.3	73.4	69.6	69.2	73.4
	4.76	73.7	74.7	70.4	67.2	67.5	70.7
Average		75.1	75.7	71.4	68.4	68.3	71.8
Eastern Gulf Coastal Plains	4.29	72.4	70.3	68.1	68.5	63.5	68.6
	4.53	77.8	76.8	71.7	73.7	65.1	73.0
	4.76	73.0	73.0	68.6	69.6	63.4	69.5
Average		74.4	73.4	69.5	70.6	64.0	70.4
Average of eastern stock		73.6	73.6	71.4	70.0	66.1	71.0
Western Gulf Coastal Plains	4.29	88.3	74.7	77.6	66.8	69.9	75.5
	4.53	85.5	75.3	78.2	67.6	72.5	75.8
	4.76	81.4	72.6	75.8	67.5	68.2	73.1
Average		85.1	74.2	77.2	67.3	70.2	74.8
Western Prarie Lands and Plateau	4.29	78.9	84.5	82.6	73.6	74.5	78.8
	4.53	82.5	87.9	84.0	78.0	79.6	82.4
	4.76	78.8	81.9	79.0	72.2	74.0	77.2
Average		80.1	84.8	81.9	74.6	76.0	79.5
Average of western stock		82.6	79.5	79.6	71.0	73.1	77.2

The variations in the tensile strength of yarn made from cotton originating in the Piedmont Plateau, Atlantic Coastal Plains, and eastern Gulf Coastal Plains conform closely to the grade of the cotton, but the tensile strength of yarn made from cotton originating in the western Gulf Coastal Plains or western Prairie Lands and Plateau does not bear the same relationship to the grade. The same relationship in the tensile strength of Low Middling and Good Ordinary is shown as in the tensile strength of yarn made from the same grades of western upland cotton in the mill tests. (See Table III and discussion on p. 6.) Cotton from crops of several seasons must be tested before a safe basis for comparison can be established.

It will be observed also that in the textile-school tests the twist constant 4.76, which was the nearest obtainable to 4.75, known as the twist standard for upland cotton of approximately 1-inch staple, did not produce yarn with a maximum tensile strength. The average tensile strength of the five grades in the different zones shows that the constant 4.53 produced stronger yarn than either 4.76 or 4.29. Constants 4.29, 4.53, and 4.76 represent, respectively, 20.12, 21.25, and 22.32 turns per inch for twist for 22's yarn. Practically the same results were found in the mill tests. (See Table III.) The twists per inch in the yarn were verified by untwisting the yarn and counting the turns per inch.

Figure 7 represents graphically the comparative tensile strength of 22's yarn, manufactured with 4.76 constant, made from the five different grades of cotton originating in the various zones (see fig. 1). The tensile strength is in pounds per skein of 120 yards with the downward stroke of the traverse moving at the rate of 12 inches per minute. The figures in the table in the lower part of the graph were taken from Table V and placed here for convenient reference.



KIND OF STOCK	M.F.	G.M.	M.	L.M.	G.O.
PIEDMONT PLATEAU	69.7	70.0	71.3	68.3	64.7
ATLANTIC COASTAL PLAINS	73.7	74.7	70.4	67.2	67.5
EASTERN GULF COASTAL PLAINS	73.0	73.0	68.6	69.6	63.4
WESTERN GULF COASTAL PLAINS	81.4	72.6	75.6	67.5	68.2
WESTERN PRAIRIE LANDS & PLATEAU	76.8	81.9	79.0	72.2	74.0

FIG. 7.—The tensile strength of 22's yarn made with 4.76 twist constant from five grades of cotton from each of the several zones. (Textile school tests.)

WEATHER, RELATIVE HUMIDITY, AND MOISTURE CONTENT DURING SPINNING TESTS.

(Mill and textile-school tests.)

The condition of the weather, relative humidity, and moisture content were taken into consideration during the entire time that the mill tests and the textile-school tests were in progress. The differ-

ences between the percentages of total waste as found in the mill tests and the total waste found in the textile-school tests (see Tables II and IV) are so great that, unless these conditions are considered, the results are confusing.

WEATHER CONDITIONS.

Table VI gives the monthly averages of the maximum and of the minimum temperatures and the precipitation in Fall River, Mass., during the months of February, March, and April, and in Raleigh, N. C., during the months of May, June, and July, 1916, while the mill tests and the textile-school tests, respectively, were in progress. These averages were derived from reports of the Weather Bureau, which show the maximum and minimum temperatures and the precipitation for each day.

TABLE VI.—*Average daily maximum and minimum outside temperatures and the total precipitation during the tests.*

Month.	Mill tests.			Month.	Textile-school tests.		
	Average maximum temperature.	Average minimum temperature.	Total precipitation.		Average maximum temperature.	Average minimum temperature.	Total precipitation.
	Degrees.	*Degrees.*	*Inches.*		*Degrees.*	*Degrees.*	*Inches.*
February	31.0	20.4	5.14	May	81.7	61.7	2.95
March	36.2	23.8	3.77	June	83.2	64.0	7.17
April	50.3	37.7	4.78	July	84.4	69.7	8.09
Average	39.2	27.3	4.56	Average	83.1	65.1	6.07

RELATIVE HUMIDITY.

During the time the cotton was being manufactured humidifiers were regulated so as to maintain as nearly as possible a constant humidity, but in the picker rooms at the mill there were no humidifiers. In each room self-recording hygrometers were used, which made complete records night and day of moisture and temperature during the test while the various grades of cotton were in the course of manufacture. Table VII shows these results.

TABLE VII.—*Relative humidity and inside temperature during the tests.*

MILL TESTS.

Kind of cotton.	Room.	M. F.		G. M.		M.		L. M.		G. O.	
		Average temperature.	Average relative humidity.	Average temperature.	Average relative humidity.	Average temperature.	Average relative humidity.	Average temperature.	Average relative humidity.	Average temperature.	Average relative humidity.
Eastern upland	Picker:										
	Opener	78.5	46.9	66.5	56.9	71.2	59.2	78.9	49.5	74.9	52.9
	Breaker	78.3	38.6	73.0	48.3	72.6	38.4	74.5	42.3	72.7	47.6
	Finisher	77.4	42.5	73.1	51.1	73.3	35.9	73.8	43.0	72.8	47.2
	Card	70.6	48.9	71.8	52 1	69.7	50.4	72.6	50.9	71.2	51.3
	Spinning	81.8	54.1	81.8	54.1	81.8	54.1	81.8	54.1	81.8	54.1
Western upland	Picker:										
	Opener	69.5	47.9	76.7	46.3	69.2	38.9	73.0	46.0	71.4	48.5
	Breaker	69.0	41.2	65.5	41.3	67.2	44.7	67.5	45.5	64.2	45.3
	Finisher	69.6	43.9	67.4	46.9	67.5	45.8	67.6	44.8	63.1	49.9
	Card	71.6	52.6	71.0	48.7	70.4	50.0	69.6	48.3	68.9	46.9
	Spinning	81.8	54.1	81.8	54.1	81.8	54.1	81.8	54.1	81.8	54.1

TEXTILE-SCHOOL TESTS.

Piedmont Plateau	Picker:										
	Opener	82.0	68.4	82.2	63.7	80.4	62.7	81.0	55.5	80.3	56.2
	Finisher	83.0	69.0	83.8	63.0	81.5	58.0	82.8	58.9	81.0	64.5
	Card [1]	84.6	65.4	78.1	60.0	78.7	53.8	78.8	56.0	79.6	59.3
Atlantic Coastal Plains	Picker:										
	Opener	76.8	63.6	78.0	58.2	82.0	60.4	80.4	60.6	82.0	61.0
	Finisher	78.0	61.3	78.0	64.5	84.0	57.9	80.8	59.8	82.0	61.6
	Card [1]	78.9	57.8	79.2	58.8	80.3	53.5	79.6	60.1	81.4	58.5
Eastern Gulf Coastal Plains	Picker:										
	Opener	80.0	66.4	80.6	65.9	85.0	57.6	89.3	57.9	83.3	55.8
	Finisher	80.0	63.5	81.8	66.6	85.3	60.9	90.0	58.0	83.0	60.3
	Card [1]	81.6	59.4	83.8	59.4	82.8	59.4	84.3	57.8	81.3	61.3
Western Gulf Coastal Plains	Picker:										
	Opener	89.3	58.1	92.0	52.7	92.0	58.5	83.6	64.1	84.1	53.9
	Finisher	90.0	57.8	91.8	54.9	92.0	60.2	83.6	63.7	85.9	53.2
	Card [1]	86.1	60.4	86.8	60.0	84.3	63.3	83.5	60.8	81.3	57.3
Western Prairie Lands and Plateau	Picker:										
	Opener	87.5	56.9	82.4	63.5	88.4	60.8	81.9	68.8	88.1	54.9
	Finisher	88.0	55.7	84.4	63.3	90.0	60.3	85.1	65.7	88.0	54.5
	Card [1]	82.7	62.7	85.4	66.4	82.2	69.0	86.5	61.0	83.8	72.8

[1] Card and spinning machinery in one large room.

MOISTURE DETERMINATIONS.

At both the mill and the textile school, samples of the cotton were selected for moisture tests from each place in the processes of manufacture where the stock was weighed. These samples were placed in air-tight cans, weighed carefully on equal arm balances sensitive to 0.05 grams, shipped to Washington, reweighed in the same manner, and then tested in the cotton-testing laboratory for moisture content. Table VIII gives the results of these tests.

TABLE VIII.—*Percentages of moisture in cotton of the different grades at various points in the cotton-manufacturing processes.*

MILL TESTS.

Kind of cotton.	Stage.			
	Warehouse.[1]	Opener picker.	Finisher picker.	Cards.
Eastern upland:				
Middling fair	8.65	9.03	7.13	5.83
Good middling	9.27	8.73	7.36	6.01
Middling	9.11	9.03	6.26	5.47
Low middling	9.17	8.83	5.83	5.63
Good ordinary	9.48	9.12	6.20	5.18
Western upland:				
Middling fair	9.30	8.47	6.68	5.60
Good middling	9.38	8.54	5.96	5.12
Middling	9.02	8.31	6.17	5.21
Low middling	8.96	8.57	6.31	5.41
Good ordinary	9.36	8.95	6.37	5.12

TEXTILE-SCHOOL TESTS.

Piedmont Plateau:				
Middling fair	6.50	.....	7.56	7.07
Good middling	6.05	.....	7.02	6.50
Middling	6.37	.....	6.49	5.56
Low middling	6.05	6.50	.....	6.39
Good ordinary	6.36	6.00	.....	6.27
Atlantic Coastal Plains:				
Middling fair	5.78	6.62	6.45	5.66
Good middling	6.57	6.04	5.92	6.53
Middling	6.74	6.52	6.44	6.12
Low middling	5.92	6.30	6.54	6.34
Good ordinary	6.22	6.33	6.65	6.59
Eastern Gulf Coastal Plains:				
Middling fair	6.32	6.16	6.70	7.15
Good middling	6.22	6.59	6.62	7.02
Middling	6.33	6.40	5.70	5.78
Low middling	7.31	7.89	6.07	5.87
Good ordinary	6.74	6.70	5.93	5.59
Western Gulf Coastal Plains:				
Middling Fair	6.87	6.44	6.10	5.81
Good Middling	6.04	6.10	5.22	6.16
Middling	6.38	6.54	6.10	6.22
Low Middling	6.22	.....	.....	6.26
Good Ordinary	6.41	6.66	5.99	5.64
Western Prairie Lands and Plateau:				
Middling Fair	6.83	6.02	5.73	6.67
Good Middling	7.02	6.64	6.58	6.64
Middling	6.59	6.70	6.69	6.78
Low Middling	6.12	7.05	.....	.....
Good Ordinary	7.16	.....	.....	.....

[1] As there was no warehouse at the textile school, the cotton was stored in the textile building.

In each case the cotton was stored for several months prior to the time the tests were begun—at Fall River in a cotton warehouse, which was not heated; at West Raleigh in the textile-school building, which was heated until warm weather. The weather at Fall River was cold and damp, with considerable snow on the ground at the time the warehouse weights were obtained. The textile-school tests were in progress at West Raleigh during the summer, the temperature was high, and, as the cotton proceeded through the manufacturing processes, practically no loss of moisture was evident.

Table IX shows in brief the average temperature, relative humidity, and the percentage of moisture in the cotton while in the warehouse, picker room, and card room, both at the mill and at the textile school.

TABLE IX.—*The average temperature, relative humidity, and percentage of moisture in the cotton during the mill and textile-school tests.*

Determination.	Mill test.			Textile-school test.		
	Warehouse.	Pickers.	Cards.	Warehouse.	Pickers.	Cards.
Average degree of temperature	36.8	70.6	70.8	80	84.6	82.2
Average relative humidity	72.8	45.1	50.0	53	60.7	60.3
Average percentage of moisture	9.17	6.44	5.40	6.47	6.33	6.28

The average moisture in the cotton when the tests were begun at Fall River was 9.17 per cent, as determined by samples taken at the time the cotton was weighed in the warehouse. The average moisture in this same cotton taken during the time it was passing through the cards was 5.40 per cent, a loss of moisture alone of 3.77 per cent of the weight of the cotton. The average moisture in the cotton when the tests were begun at West Raleigh, N. C., was 6.44 per cent, as determined by samples taken at the time it was weighed in the warehouse. The average moisture in this same cotton while it was passing through the cards was 6.28 per cent, a loss of moisture of only 0.16 per cent of the weight of the cotton.

Referring to Tables II and IV, it will be observed that the invisible waste at the mill ranged from a 3 per cent to a 5 per cent loss, while at the textile school there was sometimes a slight gain and sometimes a slight invisible loss. If the waste percentages were corrected for moisture content, the results would be practically the same in each case. These findings also emphasize the need of an exact knowledge of the moisture content of cotton in the various stages of handling and marketing, and of maintaining proper atmospheric conditions while it is in the course of manufacture.

MANUFACTURING PROPERTIES.

In determining the comparative manufacturing properties of the different grades of cotton it was found that better comparisons could be made by manufacturing the cotton representing all of the different grades into the same number of yarn. This method, while not conforming altogether to the general practices of the trade, simplified the comparisons and eliminated a number of factors which otherwise would have involved changes in the speeds, settings, and twist per inch in the yarn. Even with the method adopted, it was difficult to obtain specific data regarding all the factors involved in the spinning qualities of the different grades. As the grades decreased in quality from Middling Fair to Good Ordinary, the amount of dirt, dust, leaf, and short fibers afloat in the air increased progressively. For instance, when stripping the cards in the mill while the Good Ordinary cotton

was being run through them it was necessary to open the windows because of the density of the dust. The use of low grade cotton is more disagreeable to the operatives; consequently it adds difficulty to the labor and mechanical problems.

A record was taken of the spinning qualities of the different grades by keeping an accurate count of the number of threads which broke. All such breakages, unless due to some mechanical defect, were charged against each grade. The following percentages of breakages on the spinning frame were found: Middling Fair, 12.1 per cent, Good Middling 13.8 per cent, Middling 14.4 per cent, Low Middling 27.5 per cent, and Good Ordinary 32.2 per cent.

These tests show that 100 pounds of raw cotton, net weight, of each of the different grades will produce the following pounds of yarn, not including the small loss which occurs in those processes subsequent to the cards: Middling Fair 91.57, Good Middling 90.95, Middling 88.93, Low Middling 87.2, and Good Ordinary 83.73 pounds. In considering the grade relations it should be remembered that there is a difference in the value of the yarns made from the various grades.

It was found by submitting a full line of samples to a number of the leading waste dealers and securing estimates of value for each sample that the value of the waste from a bale of cotton representing one grade is practically the same as the value of the waste from a bale of cotton representing any other grade, in that the price and quantity vary inversely. Any increase or decrease in the waste percentage causes a corresponding increase or decrease in the cost per pound of the manufactured product. A wasty cotton also produces an inferior product.

BLEACHING TESTS OF YARN.

Portions of the yarns that were made from Middling Fair, Good Middling, Middling, Low Middling, and Good Ordinary of both eastern upland and western upland cotton in the mill tests, as well as cloth made from various combinations of these yarns, were tested for the bleaching properties. The tests were conducted on a commercial scale in a bleachery, and the results were checked subsequently in the New Bedford Textile School. The methods followed were those that are in common use.

TESTS AT BLEACHERY.

Scouring.—The skeins of yarns were placed in a cloth bag near the center of a circulating kier, loaded with other goods, and were treated for 12 hours at 13 pounds pressure with a 2-degree Twaddell solution of sodium hydroxide containing 10.75 grams NaOH per liter. The samples were then washed with water five times while in the kier, which eliminated practically all alkali from the material. The goods were kept wet for some time before a bleaching vat was available,

after which they were hydro-extracted and treated in a circulating vat.[1]

Bleaching.—The goods were placed in the center of a 300-pound load of commercial yarns, the ratio of liquor to the goods being in weight 10 to 1, and treated for 1½ hours with a 2.5-degree Twaddell solution of bleaching powder containing 1.26 [2] grams of chlorine per liter. The goods were treated with a 1-degree Twaddell solution of sulphuric acid containing 6.80 [2] grams per liter and then washed for 30 minutes. Finally, the goods were soaped 30 minutes in a solution containing 2 per cent [3] of 88 per cent soap chips. The skeins were blued by treating them 20 minutes in a water solution containing 0.055 per cent of methylene blue. After the skeins were hydro-extracted they were dried for 3½ hours on a truck drier heated to a temperature of 120° F.

Qualities of bleach.—The grades in the order of whiteness obtained by bleaching are as follows, beginning with the best:

Good Middling, western.
Good Middling, eastern.
Middling Fair, western.
Middling Fair, eastern.
Middling, western.
Middling, eastern.
Low Middling, western.
Low Middling, eastern.
Good Ordinary, western.
Good Ordinary, eastern.

Cotton yarn made from Low Middling western upland and Low Middling eastern upland cotton produced goods having a somewhat slaty hue. Yarns made from the Good Ordinary, both eastern upland and western upland cotton, did not bleach satisfactorily in that a decided bluish cast was apparent.

TEXTILE-SCHOOL TESTS.

Subsequent tests were made in the New Bedford Textile School in order to check the determinations made in the commercial bleachery. They included tests of the whiteness, tensile strength, weight losses, and moisture content at each operation.

Scouring.—The scouring [4] was done with 10 per cent soda ash and 5 per cent soap. The goods were boiled five hours, rinsed well with hot water at 75° C. and then in cold water at 23° C., after which they were acidulated with 1 per cent solution of sulphuric acid, rinsed freely in water until free from acid, and dried.

Bleaching.—Samples of the wet yarn were taken after the last rinsing and bleached at 23.3° C. in a solution of bleaching powder containing 2 grams per liter of chlorine. The goods were left in this

[1] This vat was constructed in such a way that the skeins were supported by rods in a comparatively loose condition, and the liquor was circulated through them by mechanical means.

[2] The liquor was kept overnight in a well-corked bottle and the analysis was made on the following morning.

[3] The percentages given in the bleaching tests are calculated on the weight of goods treated unless otherwise stated.

[4] The volume of liquor used in the textile-school tests was fifteen times the weight of the goods treated.

solution for 43 minutes, after which they were rinsed freely in cold water, soured in a 1 per cent solution of acetic acid, and rinsed again. As there was still a slight trace of chlorine, the goods were treated in a 2.5° Twaddell solution of hyposulphite of soda at 22° C. for 30 minutes. They were then rinsed freely in cold water and dried.

This method does not take into consideration the actual time that would be required to bleach the different yarns made from the different grades of cotton. The yarns were all treated under identical conditions, and at the same time. The lower grades could have been bleached more satisfactorily if the factors of time, strength of bleach liquor, and temperature had been altered. The treatment of all the material in the same way, however, gave a satisfactory basis for comparison.

These tests substantiated the following conclusions reached in the tests made in the commercial bleachery: The yarns made from Middling Fair and Good Middling were practically identical in color after bleaching; the yarns made from Middling were not quite as glossy or "bloomy" in their appearance, but for commercial purposes produced satisfactory results; the yarns made from Low Middling gave a slightly slaty color when compared closely with the higher grades; and the yarns made from Good Ordinary did not bleach satisfactorily, i. e., under the same conditions, in that they had a decided slaty bluish cast when compared closely with the yarns from the Middling cotton or that of better grades.

While these tests were in progress, moisture determinations were made from time to time. Bleaching, calculated on a dry basis, caused an average loss in weight for the eastern cotton of 4.69 per cent in the textile school test and 5.14 per cent in the commercial test.

The average loss in weight due to bleaching of the western cotton was 4.78 per cent in the textile-school test and 5.24 per cent in the mill test. This difference probably was caused by the 12-hours caustic-soda boil under pressure in the mill tests. Several different concentrations of bleaching liquor were used in the textile-school test; namely, 1, 2, 3, and 4 grams per liter of chlorine. There was practically no difference in weight losses due to bleaching.

The loss in tensile strength due to the bleaching processes was 12.25 per cent in the eastern cotton, and 16.40 per cent in the western cotton. These results were influenced somewhat by a slight difference in the moisture content, but this difference was such that it would serve further to increase the loss in the western cotton. The results seem to indicate that in the bleaching processes chemicals act more readily on upland cotton grown west of the Mississippi River than on corresponding grades of eastern upland cotton, because

under the same conditions the strength of the yarn made from the western upland cotton was affected more readily and a better bleach was obtained.

BLEACHING TESTS OF PIECE GOODS.

MILL TESTS.

Warp and filling yarns made from each of the five grades of upland cotton produced east and west of the Mississippi River, were woven into cloths composed of different combinations of warp and filling. These were marked carefully for identification, and bleached in a commercial bleachery. Exact duplicates were retained "in the gray" for comparative purposes. The goods were given a plain "sheeting finish," that is, they were scoured twice in a closed kier, bleached, starched, dried, and calendered.

Scouring.—In the first boiling process the cloth was placed in a horizontal wagon kier, near the center of a 6,500-pound lot of similar cloth. The steam turned on, and a good circulation of the liquor was established by a steam injector for 45 minutes. A 2-degree Twaddell solution of sodium hydroxide containing 8.9 grams per liter was used. The circulation was continued at 6 to 7 pounds pressure for 10 hours. The goods were cooled in the kier before the latter was opened by flushing with water.

Washing and scouring.—The goods were washed [1] through cold water, acidulated [2] in a scouring machine, with a 1-degree Twaddell solution of sulphuric acid, containing 11.42 grams per liter, piled on a wooden rack 30 minutes, to allow the acid to act, again washed, and run into a vertical kier.

Second boiling process.—The goods were placed about one-third of the way down from the top of a vertical kier, containing 10,000 pounds of cloth which was being treated for commercial purposes. The liquor used in this kier was a 1-degree Twaddell solution of caustic soda containing 5 grams per liter. Good circulation and proper temperature were established within $1\frac{1}{4}$ hours, and then the material was boiled for 9 hours at 6 to 7 pounds pressure, after which the kier was flushed twice with cold water and the goods run into a log washing machine.

Washing and bleaching.—The goods were washed twice with a plentiful supply of clean water, and the cloth was piled for examination. The material was then run through a $\frac{3}{4}$-degree Twaddell

[1] All the washing in the piece goods tests was done in a standard type "log" washer having a top press roll of wood about 18 inches in diameter and pit allowing a depth of 2 feet of water. The speed of these machines was from 80 to 90 yards per minute.

[2] The acidulating was done in a regular scouring machine consisting of a pit containing acid and a heavy set of squeeze rolls, with compound lever set at approximately 500 pounds pressure. This machine was provided with an automatic folding device by means of which about 800 yards were kept continuously immersed in the acid.

bleaching-powder solution[1] containing 2.3 grains of available chlorine per liter. It was allowed to stand in a pile until a good white was obtained, the time required being 1 hour and 5 minutes. The goods were then washed twice with clean water, and squeezed in a 4-roll water mangle at a speed of 124 yards per minute, with the lever set for a light pressure of approximately 500 pounds.

Starching.—The goods were passed at a speed of 120 yards per minute through a starch mangle, which contained the following mixture: 45 pounds of cornstarch; 10 ounces of bluing,[2] 20 ounces of tint.[3]

These ingredients were mixed with 100 gallons of water heated to a temperature of 180° F., and cooked to a paste, a subsequent analysis of which showed 3.015 per cent of solids.

Drying and calendering.—The goods were dried on a set of copper cylinders, after which they were allowed to cool, moistened on a rotary brush type sprinkler and calendered cold at a speed at 104 yards per minute on a three-roll calender. A rigid bow expander was used to obtain the width. Finally, the goods were measured off on a yarding machine, inspected, and packed.

By selecting the 10 gray pieces of cloth woven in both the warp and filling from each of the five different grades of eastern upland cotton and the five different grades of western upland cotton, it was comparatively easy to arrange these samples in the order of the grades of cotton from which they were produced. The samples of the bleached cloth, however, produced from the Good Middling and Middling Fair cotton were indistinguishable as to the degree of whiteness; the bleached cloth representing the Middling cotton could be distinguished from the Good Middling and Middling Fair by very close comparison; the cloth made from Low Middling bleached comparatively well, but with a less degree of lustre and brightness; while the cloth produced from the grade of Good Ordinary cotton could be distinguished readily by the bluish cast.

Each of these 10 samples of bleached cloth was presented to a number of cloth brokers, and it was the general opinion that the cloth representing the grades of Middling Fair, Good Middling, and Middling were of the same money value, but that preference would be given in the markets to cloth produced from the higher grades. The bleached cloth made from Low Middling and Good Ordinary would not be accepted as of equal value with that produced from the higher grades.

[1] The bleaching machine was similar to the scouring machine, but ran at a speed of from 100 to 110 yards per minute. From 100 to 500 yards of cloth were kept in the bleaching solution.

[2] A solution of blue basic dye.

[3] A solution of a reddish-blue basic dye.

COMPARISON OF THE RESULTS OF SPINNING TESTS OF THE OLD PERMISSIVE COTTON GRADES WITH THE PRESENT OFFICIAL COTTON STANDARDS.

The spinning tests of the old permissive grades[1] were conducted in a representative mill at Danville, Va., in the fall of 1913 on cotton from the 1912 crop. The spinning tests on the present Official Cotton Standards were conducted at Fall River, Mass., in the spring of 1916 on cotton from the 1914 crop. In each case approximately 110 bales were used, representing Middling Fair, Good Middling, Middling, Low Middling, and Good Ordinary. The old permissive grades were established by the Secretary of Agriculture in February, 1909, and copies were distributed and used until they were superseded by the present Official Cotton Standards of the United States, established and promulgated December 14, 1914, and reestablished and repromulgated August 11, 1916.

Table X gives the visible, invisible, and total waste percentages and the tensile strength of the yarn of the different grades for each test. The waste percentages in each case represent the average of the results obtained from both the eastern and western cottons.

TABLE X.—*The average visible, invisible, and total waste percentages and the tensile strength of 22's warp yarn of the old permissive cotton grades compared with the present Official Cotton Standards (mill tests).*

Determination.	Old permissive cotton grades, 1912 crop.					Present Official Cotton Standards, 1914 crop.				
	M. F.	G. M.	M.	L. M.	G. O.	M. F.	G. M.	M.	L. M.	G. O.
Total visible waste through cards[1]	5.12	5.97	6.88	9.53	11.32	4.61	5.32	6.85	8.12	10.67
Total invisible waste through cards[1]	2.67	2.75	3.66	4.21	4.42	3.82	3.73	4.22	4.68	5.60
Total waste	7.79	8.72	10.54	13.74	15.74	8.43	9.05	11.07	12.80	16.27
Breaking strength, 22's warp yarn, in pounds per 120 yards.	74.5	71.4	67.7	65.4	60.6	78.3	77.4	74.8	70.4	70.8

[1] Based on net weights fed to opener picker.

It will be observed that somewhat less visible waste was discarded from the different grades in the tests on the present Official Cotton Standards than on the old permissive grades; the invisible waste was greater and more nearly uniform for the various grades of the present Official Cotton Standards, while the total waste percentages, as shown by figure 8, were very similar.

The moisture content of the cotton representing the Official Cotton Standards when weighed at the warehouse just prior to the

[1] These spinning tests were planned by Dr. N. A. Cobb, agricultural technologist, of the Bureau of Plant Industry, and were conducted by Messrs. D. E. Earle and W. S. Dean.

beginning of the tests and when weighed at the cards was 9.17 and 5.40 per cent, respectively, while the moisture content of the old permissive cotton grades at the same places was 7.95 and 6.06 per cent, respectively. These differences explain in part the differences described as invisible waste percentages.

The spinning tests of the Official Cotton Standards showed that the western cotton was approximately 1 per cent more wasty than the eastern cotton, while with the old permissive grades the reverse was shown. In both tests the yarn (22's) made from the western cotton was approximately 3 pounds per skein stronger than that made from the eastern cotton.

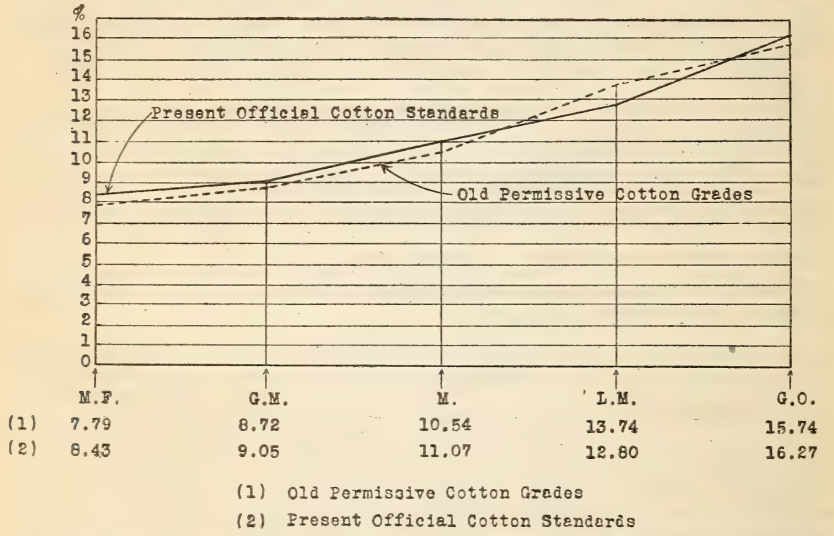


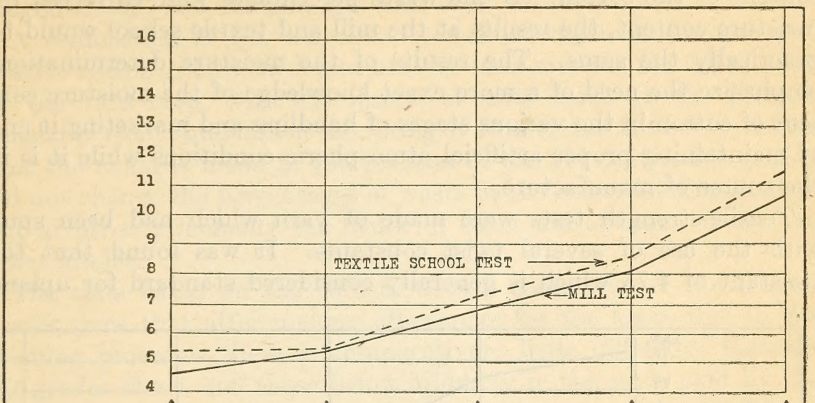
FIG. 8.—Total waste percentages of the old permissive cotton grades compared with those in the present Official Cotton Standards. (Mill tests.)

In this comparison a very close relation is shown to exist, especially with reference to the percentage of waste in each corresponding grade. While the tests were made on different crops under somewhat different conditions, a comparison of the results obtained in the two tests indicates that the changes which were made in the new grades made practically no difference in the waste percentages, but involved principally a change in the degree or depth of color, particularly in the lower grades.

SUMMARY.

This bulletin gives the results of manufacturing tests made of cotton representing Middling Fair, Good Middling, Middling, Low Middling, and Good Ordinary of the Official Cotton Standards of the United States. The spinning and weaving tests were conducted in a cotton mill in the North, and check tests were made in a

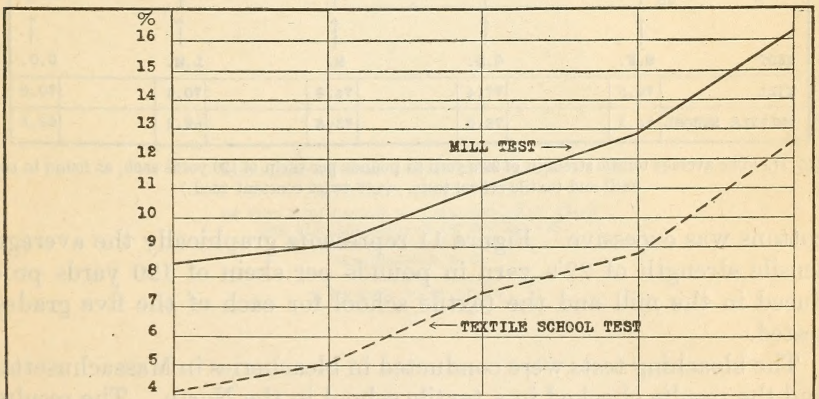
textile school, in the South, with a portion of the same bales of cotton. At each place, the different grades were tested under as nearly identical conditions as was possible.



TEST	M.F.	G.M.	M.	L.M.	G.O.
MILL	4.61	5.32	6.85	8.12	10.67
TEXTILE SCHOOL	5.34	5.46	7.33	8.52	11.46

FIG. 9.—The visible waste percentages as found in mill and textile school tests.

The results of the spinning tests are summarized graphically in figures 9, 10, and 11. Figure 9 represents the average visible waste



TEST	M.F.	G.M.	M.	L.M.	G.O.
MILL	8.43	9.05	11.07	12.80	16.27
TEXTILE SCHOOL	4.17	5.06	7.44	8.74	12.55

FIG. 10.—The combined visible and invisible waste percentages, as found in the mill and textile school tests.

discarded in the manufacturing processes in both the textile school and mill tests for each of the five grades tested, while figure 10 represents the total waste percentages. The differences in the storage

conditions as well as in the weather and location of the mill and textile school explain the differences in the waste percentages shown in figure 10, which represent largely the differences in the moisture content of the cotton. If the waste percentages were corrected for moisture content, the results at the mill and textile school would be practically the same. The results of the moisture determinations emphasize the need of a more exact knowledge of the moisture content of cotton in the various stages of handling and marketing it and of maintaining proper artificial atmospheric conditions while it is in the course of manufacture.

Tensile-strength tests were made of yarn which had been spun with the use of several twist constants. It was found that the constant of 4.75 which is generally considered standard for upland

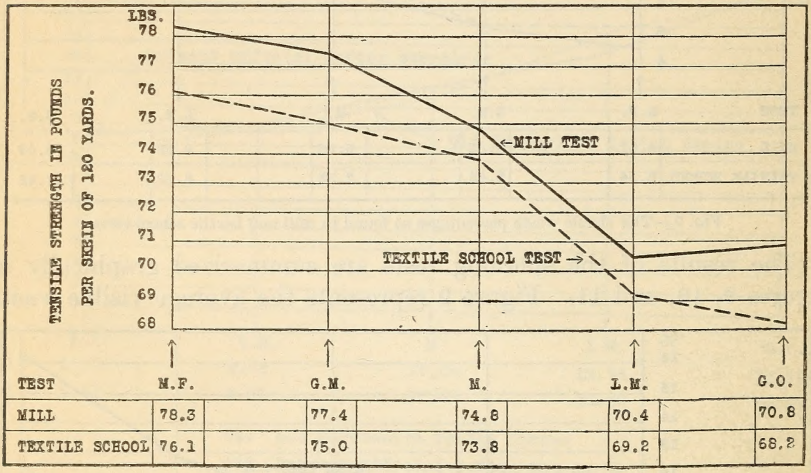


FIG. 11.—The average tensile strength of 22's yarn in pounds per skein of 120 yards each, as found in the mill and textile school tests. (4.75 twist constant used.)

cottons was excessive. Figure 11 represents graphically the average tensile strength of 22's yarn in pounds per skein of 120 yards produced in the mill and the textile school for each of the five grades tested.

The bleaching tests were conducted in bleacheries in Massachusetts, and the results checked in a textile school in the North. The results showed that when the goods made from each grade were bleached under identical conditions Middling Fair and Good Middling were practically identical in color. The goods made from Middling did not produce quite as pure a white as Middling Fair and Good Middling, but for commercial purposes gave satisfactory results; the goods made from Low Middling gave a slightly slaty color when closely compared with the other grades, while the goods made from Good Ordinary were easily distinguished by a slaty, bluish

cast when compared with the goods made from Middling cotton or that of a better grade. The lower grades might have been bleached more satisfactorily if in some of the processes the factors of time, concentration, and temperature had been altered.

A comparison of the waste and tensile strength of the old permissive cotton grades, as determined by tests made in the fall of 1913 on the 1912 crop, with the results of tests made on the present Official Cotton Standards in the spring of 1916 on the 1914 crop, shows that the changes made in the revision of the old permissive grades did not change the percentages of waste in the corresponding grades, but involved principally the factor of color and affected chiefly the lower grades.

The tests based on the Official Cotton Standards of the United States show that after making allowances for the losses due to the cleaning processes there is comparatively little difference between the grades above and those below Middling in the price paid by the manufacturer for each pound of the usable cotton obtained from bales of the different grades, but that there is a difference in the intrinsic value per pound of the manufactured product. Accordingly, on the basis of quotations and values at the time of the tests, the inducement in the price paid to the farmer for the production of high-grade cotton was not commensurate with the greater value to the manufacturer of the product derived from such cotton.

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